Supplementary Material

The association between ambient temperature and mortality in South Africa: a time-series analysis

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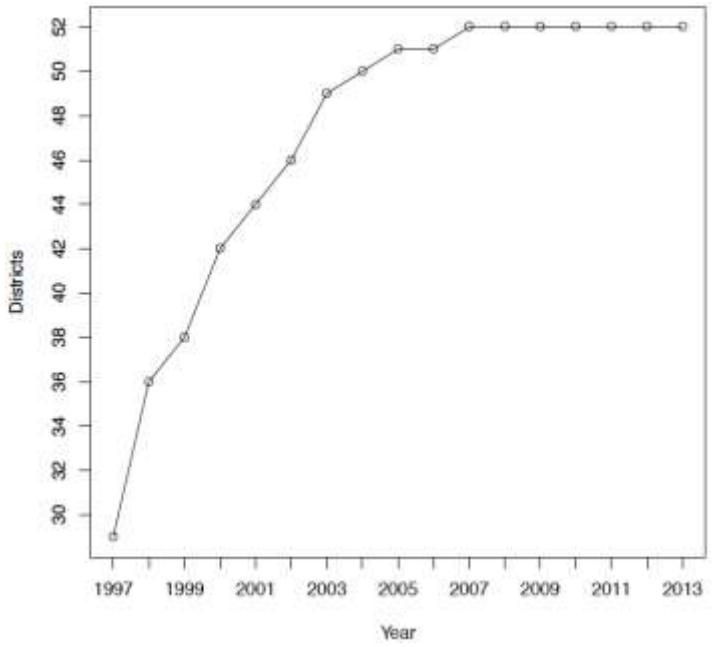
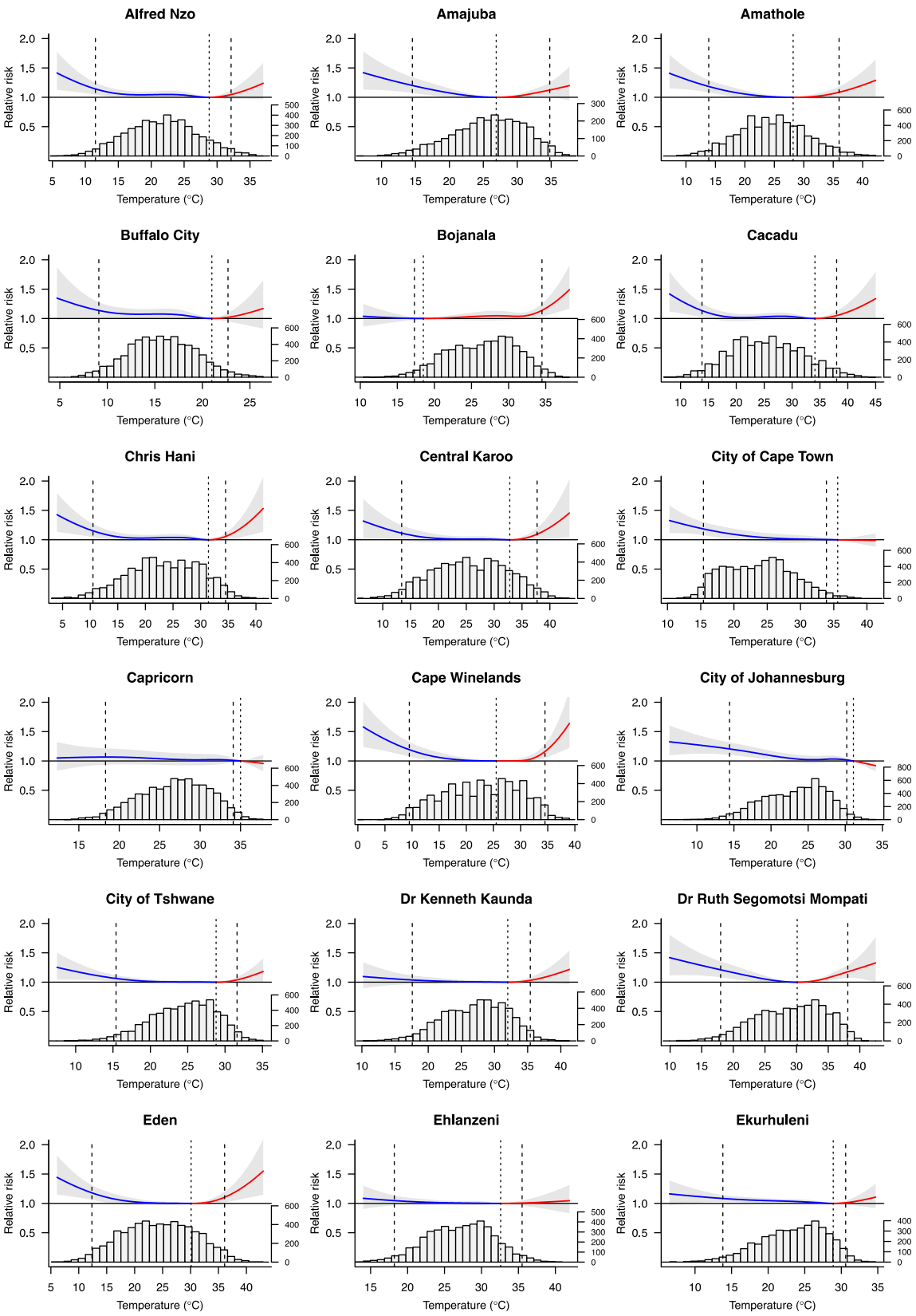
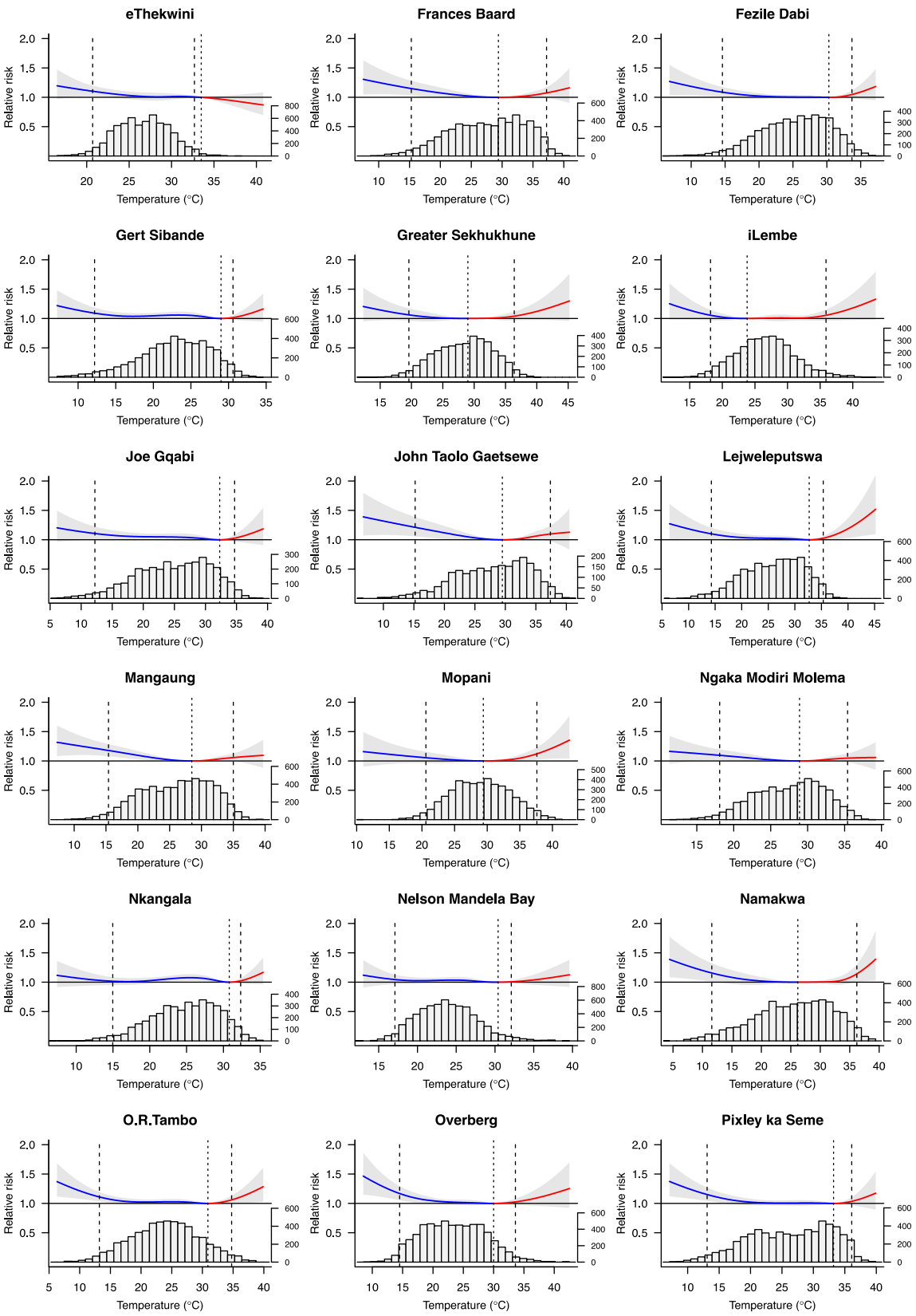


Figure S1. Number of districts (n=52) with temperature data over the study period.


Alfred Nzo
Amajuba
Amathole
Buffalo City
Bojanala
Cacadu
Chris Hani
Central Karoo
City of Cape Town
Capricorn
Cape Winelands
City of Johannesburg
City of Tshwane
Dr Kenneth Kaunda
Dr Ruth Segomotsi Mompati
Eden
Ehlanzeni
Ekurhuleni
Relative risk
Temperature (°C)


eThekwini
Frances Baard
Fezile Dabi
Gert Sibande
Greater Sekhukhune
iLembe
Joe Gqabi
John Taolo Gaetsewe
Lejweleputswa
Mangaung
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Ngaka Modiri Molema
Nkangala
Nelson Mandela Bay
Namakwa
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Pixley ka Seme
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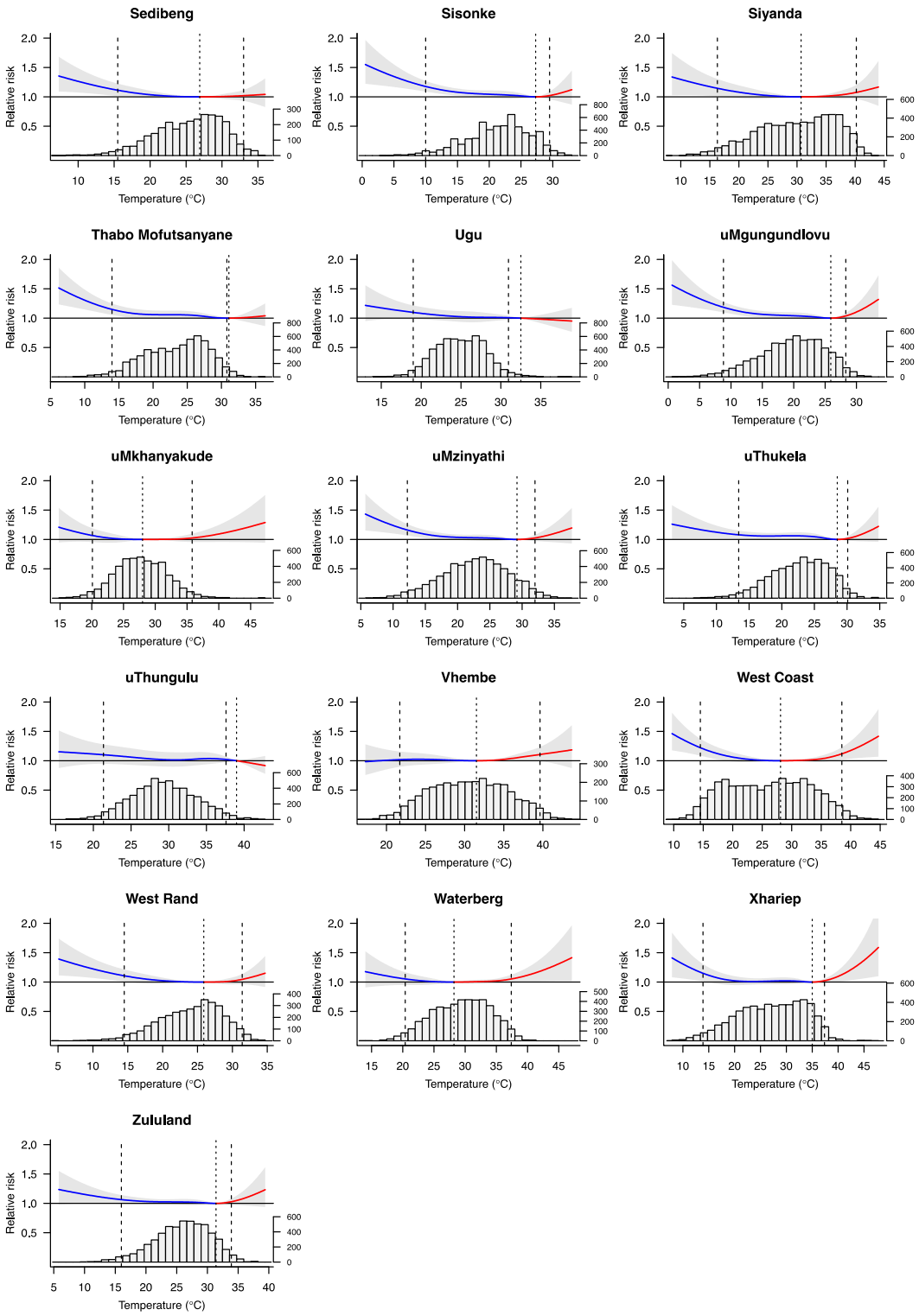

Figure S2. Best-linear unbiased predictions of the overall cumulative exposure response associations for all 52 districts in South Africa. The light grey vertical line shows the minimum mortality temperature and the darker grey vertical lines show the 2.5th and 97.5th temperature percentiles. The secondary y-axis (and associated histogram) shows the attributable deaths at each temperature.

Table S1. Deaths (all-age, all-cause), average daily maximum temperature (Temp), minimum mortality temperatures and percentiles (MMTs and MMPs), relative risks at select temperatures and total attributable fractions and deaths from heat and cold.

	Province[a]	Deaths		Temp	MMP	MMT	Relative risk		Attributable fraction (%)		Attributable deaths[d]	
		Total[b]	Included[c]				1st %tile	99th %tile	Cold	Heat	Cold	Heat
Alfred Nzo	EC	114,467	94,731	21.6	91	28.8	1.20	1.10	4.2	0.3	4,799	326
Amajuba	KZN	95,209	50,282	25.7	55	26.9	1.24	1.14	2.9	1.5	2,734	1,448
Amathole	EC	235,000	229,182	24.7	72	28.2	1.23	1.14	3.1	0.7	7,266	1,644
Bojanala	NW	215,910	183,444	26.5	5	18.5	1.01	1.21	0.0	3.5	42	7,522
Buffalo City	EC	183,536	181,276	15.8	93	21.0	1.18	1.06	6.0	0.2	10,947	299
Cacadu	EC	76,341	70,821	25.5	90	34.1	1.21	1.11	3.0	0.3	2,326	252
Cape Winelands	WC	101,671	100,689	22.8	60	25.5	1.25	1.29	2.7	1.1	2,754	1,149
Capricorn	LIM	205,787	197,313	26.8	99	35.0	1.07	1.00	3.2	0.0	6,671	-23
Central Karoo	WC	13,873	13,754	25.7	84	32.8	1.16	1.16	2.0	0.6	279	83
Chris Hani	EC	141,243	134,875	23.4	88	31.4	1.20	1.12	3.4	0.4	4,735	605
City of Cape Town	WC	447,086	444,753	23.7	99	35.6	1.21	1.00	6.0	0.0	26,950	-10
City of Johannesburg	GT	553,340	538,957	23.2	99	31.1	1.23	1.00	6.0	0.0	33,097	-102
City of Tshwane	GP	370,121	360,724	24.4	84	28.8	1.10	1.07	1.0	0.3	3,613	1,023
Dr Kenneth Kaunda	NW	156,481	146,114	27.2	83	32.0	1.05	1.06	0.9	0.2	1,412	324
Dr Ruth Segomotsi Mompati	NW	84,956	75,323	29.1	52	30.1	1.26	1.20	3.3	2.5	2,799	2,086
Eden	WC	82,205	81,635	24.3	79	30.1	1.24	1.17	2.6	0.7	2,155	572
Ehlanzeni	MP	258,712	216,835	27.1	89	32.6	1.06	1.01	1.0	0.0	2,674	111
Ekurhuleni	GT	449,732	338,655	23.4	90	28.9	1.10	1.03	3.2	0.1	14,199	388
eThekwini	KZN	582,400	578,713	26.6	99	33.5	1.13	1.00	2.8	0.0	16,226	-130
Fezile Dabi	FS	106,758	84,913	25.3	82	30.3	1.13	1.08	1.3	0.3	1,394	343
Frances Baard	NC	80,748	79,737	27.6	56	29.4	1.18	1.09	2.5	1.0	1,984	772
Gert Sibande	MP	201,085	168,584	22.8	92	29.0	1.13	1.04	4.1	0.1	8,200	251
Greater Sekhukhune	LIM	154,245	108,751	28.4	51	29.0	1.09	1.06	0.9	0.4	1,326	655
iLembe	KZN	96,687	59,964	26.6	26	23.8	1.09	1.11	0.5	0.8	442	797
Joe Gqabi	EC	70,534	48,732	24.9	90	32.3	1.14	1.05	3.8	0.2	2,681	123
John Taolo Gaetsewe	NC	38,604	17,535	27.9	55	29.5	1.26	1.11	3.5	1.5	1,335	565
Lejweleputswa	FS	172,065	139,364	26.0	89	32.7	1.14	1.05	2.5	0.2	4,377	300
Mangaung	FS	186,482	184,144	26.1	61	28.5	1.21	1.07	3.7	0.8	6,860	1,404
Mopani	LIM	154,962	123,881	29.0	53	29.4	1.07	1.16	0.9	1.3	1,452	2,000

Namakwa	NC	16,347	16,228	25.5	51	26.2	1.21	1.20	1.8	1.1	295	177
Nelson Mandela Bay	EC	215,125	213,805	23.8	95	30.4	1.06	1.02	2.6	0.1	5,594	161
Ngaka Modiri Molema	NW	158,209	156,926	27.5	56	28.9	1.12	1.05	1.9	0.7	3,006	1,145
Nkangala	MP	195,810	147,481	24.8	92	30.8	1.03	1.05	4.0	0.2	7,864	320
O.R.Tambo	EC	194,455	181,489	24.0	89	30.9	1.16	1.10	2.7	0.4	5,163	730
Overberg	WC	30,406	30,243	23.4	89	30.0	1.22	1.06	3.7	0.2	1,129	58
Pixley ka Seme	NC	42,781	42,449	26.2	83	33.2	1.20	1.05	1.9	0.2	829	103
Sedibeng	GT	174,249	95,186	25.4	57	26.9	1.17	1.03	1.6	0.2	2,836	414
Sisonke	KZN	92,073	85,597	21.4	88	27.3	1.24	1.04	3.9	0.2	3,622	168
Siyanda	NC	47,034	46,271	30.0	50	30.7	1.19	1.09	2.0	1.1	921	509
Thabo Mofutsanyane	FS	196,340	195,601	23.4	98	31.1	1.21	1.00	5.1	0.0	10,102	11
Ugu	KZN	169,571	158,976	24.9	99	32.5	1.12	1.00	3.2	0.0	5,451	-17
uMgungundlovu	KZN	227,558	223,668	19.7	89	25.9	1.26	1.08	4.3	0.3	9,899	637
uMkhanyakude	KZN	92,434	75,570	27.8	52	28.0	1.10	1.05	0.8	0.3	719	240
uMzinyathi	KZN	106,810	103,995	22.7	89	29.2	1.21	1.05	3.4	0.2	3,633	198
uThukela	KZN	140,953	127,948	22.7	91	28.5	1.10	1.04	4.4	0.1	6,203	199
uThungulu	KZN	182,682	167,855	29.4	99	39.0	1.12	1.00	3.5	0.0	6,450	-56
Vhembe	LIM	134,651	82,998	30.6	57	31.5	1.01	1.13	0.8	1.4	1,011	1,849
Waterberg	LIM	74,795	60,366	29.4	40	28.2	1.08	1.07	0.6	0.7	450	535
West Coast	WC	58,114	57,769	26.1	58	28.1	1.27	1.17	3.8	1.1	2,214	631
West Rand	GT	160,416	100,396	24.1	61	25.9	1.16	1.07	1.5	0.4	2,362	626
Xhariep	FS	50,127	44,861	27.0	89	35.0	1.22	1.05	2.2	0.2	1,118	93
Zululand	KZN	117,950	107,315	25.9	89	31.4	1.09	1.05	2.0	0.2	2,411	198

[a] EC = Eastern Cape, FS = Free State, GT = Gauteng, KZN = KwaZulu-Natal, LIM = Limpopo, MP = Mpumalanga, NC = Northern Cape, NW = Northwest, WC = Western Cape.

[b] Excludes stillbirths, deaths without location information and nonsensical dates of death.

[c] Deaths were included for all days with temperature data.

[d] Based on total deaths.

Table S2. Attributable mortality fraction from cold and heat by district, computed for "extreme" temperature ranges below and above the 2.5th and 97.5th temperature percentiles, respectively.

		t ≤ 2.5th	**t ≥ 97.5**
Alfred Nzo	Cold (%)	0.44 (0.16,0.70)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.20 (-0.06,0.46)
Amajuba	Cold (%)	0.51 (0.22,0.76)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.29 (0.00,0.57)
Amathole	Cold (%)	0.50 (0.25,0.70)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.30 (0.00,0.61)
Bojanala	Cold (%)	0.02 (-0.13,0.14)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.43 (0.15,0.75)
Buffalo City	Cold (%)	0.39 (0.01,0.68)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.14 (-0.25,0.47)
Cacadu	Cold (%)	0.48 (0.16,0.79)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.22 (-0.06,0.51)
Cape Winelands	Cold (%)	0.57 (0.27,0.82)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.51 (0.29,0.87)
Capricorn	Cold (%)	0.17 (-0.23,0.54)	0.01 (-0.02,0.04)
	Heat (%)	0.00 (0.00,0.00)	-0.01 (-0.06,0.03)
Central Karoo	Cold (%)	0.37 (0.01,0.72)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.32 (0.04,0.69)
Chris Hani	Cold (%)	0.46 (0.18,0.71)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.28 (0.06,0.51)
City of Cape Town	Cold (%)	0.48 (0.25,0.70)	0.00 (-0.02,0.03)
	Heat (%)	0.00 (0.00,0.00)	0 (-0.02,0.02)
City of Johannesburg	Cold (%)	0.51 (0.28,0.70)	0.02 (-0.01,0.05)
	Heat (%)	0.00 (0.00,0.00)	-0.02 (-0.05,0.00)
City of Tshwane	Cold (%)	0.24 (0.09,0.37)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.17 (-0.03,0.36)
Dr Kenneth Kaunda	Cold (%)	0.13 (-0.13,0.35)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.12 (-0.05,0.29)
Dr Ruth Segomotsi Mompati	Cold (%)	0.55 (0.26,0.82)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.44 (0.18,0.71)
Eden	Cold (%)	0.52 (0.20,0.77)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.34 (0.09,0.61)
Ehlanzeni	Cold (%)	0.14 (-0.15,0.37)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.03 (-0.20,0.22)
Ekurhuleni	Cold (%)	0.26 (0.06,0.44)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.06 (-0.08,0.21)
eThekwini	Cold (%)	0.28 (0.02,0.51)	0.01 (-0.01,0.02)
	Heat (%)	0.00 (0.00,0.00)	-0.02 (-0.07,0.01)
Fezile Dabi	Cold (%)	0.31 (0.06,0.48)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.17 (-0.06,0.41)
Frances Baard	Cold (%)	0.41 (0.11,0.69)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.20 (-0.08,0.50)
Gert Sibande	Cold (%)	0.30 (0.03,0.53)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.10 (-0.08,0.28)

Greater Sekhukhune	Cold (%)	0.22 (-0.08,0.48)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.14 (-0.08,0.38)
iLembe	Cold (%)	0.20 (-0.05,0.38)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.27 (-0.10,0.68)
Joe Gqabi	Cold (%)	0.31 (-0.01,0.57)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.11 (-0.10,0.33)
John Taolo Gaetsewe	Cold (%)	0.55 (0.21,0.88)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.22 (-0.15,0.59)
Lejweleputswa	Cold (%)	0.32 (0.03,0.57)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.12 (-0.01,0.25)
Mangaung	Cold (%)	0.48 (0.23,0.70)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.13 (-0.04,0.31)
Mopani	Cold (%)	0.17 (-0.07,0.40)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.35 (0.10,0.66)
Namakwa	Cold (%)	0.50 (0.07,0.91)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.43 (0.00,0.85)
Nelson Mandela Bay	Cold (%)	0.14 (-0.11,0.36)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.07 (-0.10,0.24)
Ngaka Modiri Molema	Cold (%)	0.30 (-0.01,0.58)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.12 (-0.10,0.35)
Nkangala	Cold (%)	0.08 (-0.16,0.30)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.13 (-0.09,0.33)
O.R.Tambo	Cold (%)	0.37 (0.14,0.56)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.25 (0.01,0.50)
Overberg	Cold (%)	0.52 (0.21,0.79)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.15 (-0.09,0.38)
Pixley ka Seme	Cold (%)	0.49 (0.18,0.78)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.12 (-0.12,0.36)
Sedibeng	Cold (%)	0.42 (0.13,0.68)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.06 (-0.25,0.35)
Sisonke	Cold (%)	0.48 (0.27,0.66)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.11 (-0.19,0.41)
Siyanda	Cold (%)	0.44 (0.06,0.75)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.21 (-0.21,0.55)
Thabo Mofutsanyane	Cold (%)	0.48 (0.25,0.71)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.01 (-0.04,0.05)
Ugu	Cold (%)	0.28 (0.00,0.51)	0.01 (-0.02,0.04)
	Heat (%)	0.00 (0.00,0.00)	-0.01 (-0.06,0.03)
uMgungundlovu	Cold (%)	0.52 (0.29,0.69)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.19 (-0.03,0.44)
uMkhanyakude	Cold (%)	0.24 (-0.08,0.50)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.14 (-0.1,0.42)
uMzinyathi	Cold (%)	0.43 (0.19,0.59)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.13 (-0.12,0.37)
uThukela	Cold (%)	0.25 (0.07,0.42)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.12 (-0.07,0.29)
uThungulu	Cold (%)	0.27 (-0.19,0.62)	0.02 (-0.02,0.06)
	Heat (%)	0.00 (0.00,0.00)	-0.03 (-0.10,0.04)
Vhembe	Cold (%)	0.03 (-0.36,0.38)	0.00 (0.00,0.00)

	Heat (%)	0.00 (0.00,0.00)	0.28 (-0.08,0.69)
Waterberg	Cold (%)	0.18 (-0.12,0.51)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.16 (-0.02,0.37)
West Coast	Cold (%)	0.58 (0.26,0.86)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.34 (0.10,0.70)
West Rand	Cold (%)	0.37 (0.11,0.58)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.16 (-0.11,0.44)
Xhariep	Cold (%)	0.49 (0.09,0.81)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.14 (0.00,0.28)
Zululand	Cold (%)	0.21 (0.00,0.41)	0.00 (0.00,0.00)
	Heat (%)	0.00 (0.00,0.00)	0.12 (-0.08,0.33)
Total	Cold (%)	0.33 (0.28,0.37)	0 (0.00,0.01)
	Heat (%)	0.00 (0.00,0.00)	0.13 (0.11,0.17)

Table S3. Results of sensitivity analysis of the modeling choices, reported as attributable fractions. Values are rounded.

Modeling choices	Total (%)	Cold (%)	Heat (%)
Main model	3.4	3.0	0.4
Knots for exposure-response: 10^{th}, 25^{th}, 75^{th}, 90^{th}	3.8	3.1	0.7
Quadratic b-spline for exposure response	3.8	3.3	0.5
Df for lag response: 6	3.3	2.8	0.4
Lag of 14 days	2.5	2.0	0.5
Lag of 28 days	5.0	4.4	0.6
Df/season control: 6	3.4	2.9	0.4
Df/season control: 10	3.9	3.6	0.3